

The *Bufo tuberosus* species group with the description of a new species from the rainforest of Côte-d'Ivoire

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The *Bufo tuberosus* species group with the description of a new species from the rainforest of Côte-d'Ivoire. - A very small species of toad similar to *Bufo tuberosus* was discovered in a collection made in West Africa by M. Lamotte in the late 1960s. In the 1980s a second specimen of this species from Côte-d'Ivoire was donated to the Muséum d'histoire naturelle de Genève. This paper describes the new species, *B. amiети*, presents additional data on *B. tuberosus*, compares these species to others and hypothesizes an origin of *B. amiети* and *B. tuberosus* by geographical isolation of a common ancestor in eastern and western blocks of equatorial rainforest separated by the V-Baoulé during past interpluvial periods.

Key-words: *Bufo* - *Bufo tuberosus* group - speciation - Côte-d'Ivoire - rain forest - West Africa - Anura.

INTRODUCTION

This paper summarizes the biology of the central African rainforest toad *Bufo tuberosus* Günther and describes a new species of the same group from the far western section of African equatorial lowland rainforest in Côte-d'Ivoire.

Bufo tuberosus, a very distinctive species from the rainforests of central Africa, was described in the mid nineteenth century. It is so morphologically different from other African *Bufo* with its usually globose parotoid glands and extreme development of spinose warts that it was placed in its own species group (Tandy, 1972; Tandy & Keith, 1972). Although *Bufo tuberosus* was described very early in the literature on African amphibians, and collections have been made by various investigators over the years, it is not a common amphibian in museum holdings. Little is known about its behavior and nothing about its genetics. This paper analyzes

morphological variation based on museum material, reports observations of its calling behavior and recordings of its mating call made in Camerounian rainforests by Amiet (1973, 1975, 1976, 1989) and by Tandy & Tandy (1976) and considers ecological features of known localities.

In the 1970's, Tandy encountered a small toad in a collection from Grabazouo, Côte-d'Ivoire made by M. Lamotte and R. Vuatroux. This is a gravid female that resembles *Bufo tuberosus* but which is half the size of adult females of that species. In 1986, J.-L. Perret received a second female of this species, collected by R. Neumeyer, from Taï, Côte-d'Ivoire. This paper describes these specimens as a new species and compares them to *Bufo tuberosus* and other species from central and western Africa. The new species is named in honor of our colleague who has contributed so much to central African herpetology, J.-L. Amiet.

Terminology and methods of data collection and analysis are given in Tandy (1972), Tandy & Keith (1972), Tandy & Tandy (1976), Largen *et al.* (1978), Tandy *et al.* (1982), Tandy *et al.* (1985) and Tandy & Feener (1985).

Data are presented in the following format: locality, geographic coordinates; sex and collection numbers of specimens; collection numbers of tape recordings; altitude; date of collection; collector.

The following abbreviations are used for collection numbers:

AMNH	American Museum of Natural History, New-York;
BM	British Museum (Natural History), London;
CAS	California Academy of Sciences, San Francisco;
CNHM	Chicago Natural History Museum, Chicago;
FM	Field Museum of Natural History, Chicago;
MBG	Mission Biologique au Gabon;
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts;
MHNB	Muséum d'histoire naturelle, Bâle;
MHNG	Muséum d'histoire naturelle, Genève;
MHNCF	Muséum d'histoire naturelle, La Chaux-de-Fonds;
MNHP	Muséum national d'histoire naturelle, Paris;
MT	Collection of M. Tandy;
MT()	Reference number of M. Tandy assigned to specimen of collection indicated within parentheses;
MT.TC.Ca	Collection of tape recordings of M. Tandy; tape cut from Cameroun;
RGMC	Registre général du Musée du Congo, Tervuren;
SMF	Natur-Museum und Forschungsintitut Senckenberg, Frankfurt;
UMMZ	Museum of Vertebrate Zoology, University of Michigan, Ann Arbor, Michigan;
ZFMK	Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn;
ZMB	Zoologisches Museum der Humboldt Universität, Berlin.

***Bufo amieti* sp. n.**

Holotype: 1 adult female (MHNG 2594.17) from lowland rainforest near Taï, Taï National Park, Côte-d'Ivoire (5° 52' N 7° 28' W, altitude 123m) collected in 1986 by R. Neumeyer.



FIG. 1. *Bufo amieti* sp. n. Holotype female (above): habitus, natural size; (below): detail of the enormous paratoid gland, tympanum and eye.

Paratype: 1 adult female (MNHP 1997 4934 = MT(P) 6141) from lowland rainforest on the Sassandra River near Grabazouo, Soubré, Côte-d'Ivoire ($5^{\circ} 50'N$ $6^{\circ} 35'W$, altitude ~150m) collected 10.XII.1967 by M. Lamotte and R. Vuatroux.

Diagnosis

A very small species of *Bufo* resembling *Bufo tuberosus* Günther, 1858, but only half the size of that species. Body measurements and their ratios indicate at least five diagnostic differences with all species to which *B. amieti* has been compared



FIG. 2. *Bufo amieti* sp. n. Holotype female: dorsal and ventral color pattern. Magnification 2X.

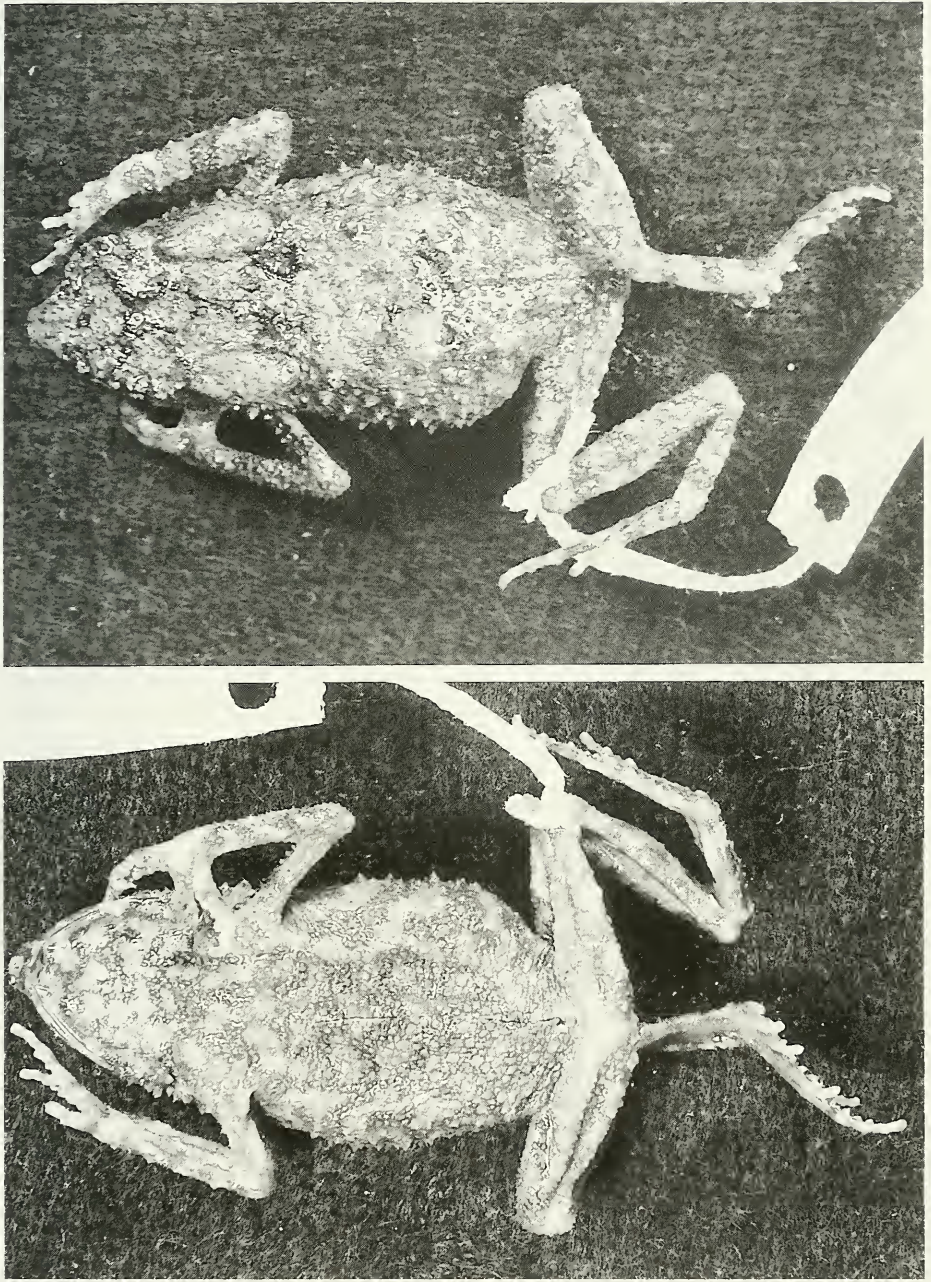


FIG. 3. *Bufo amieta* sp. n. Paratype female; dorsal and ventral color pattern. Magnification 2X.

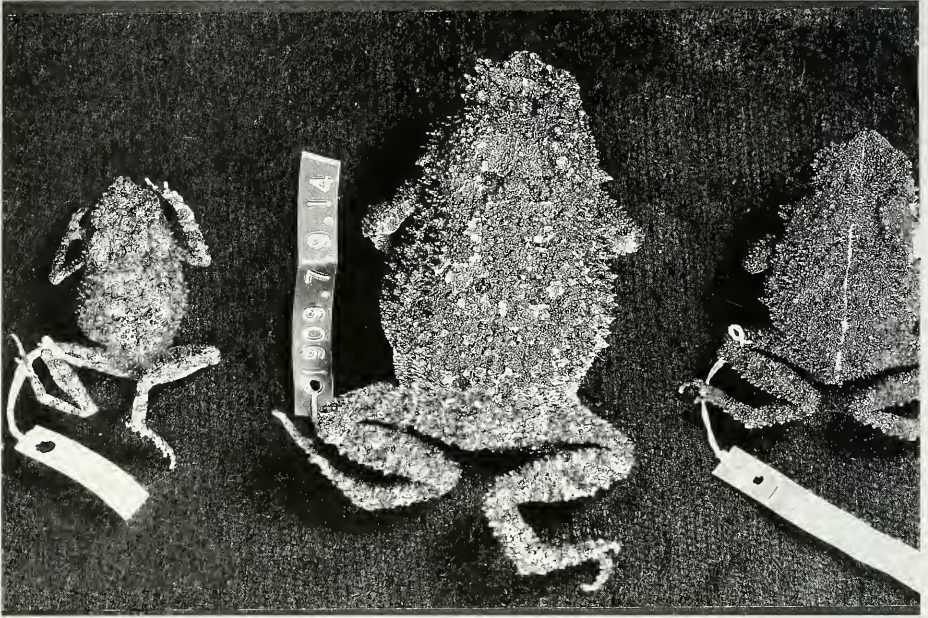


FIG. 4. *Bufo amieti* sp. n. female (paratype: MHNP 1997 4934); snout-urostyle length 35.9 mm. Grabazouo, Soubré. Côte d'Ivoire; *Bufo tuberosus* female (BM 1909.7.9.14); SU 65.8 mm. Efangono, Cameroun; *B. tuberosus* male (BM 1934.12.1.14); SU 45.0 mm. Lomié District, Cameroun.

(Tables 1 - 3). Comparisons have been made with all species of *Bufo* known from the geographic area concerned, west and central Africa, and with all members of the *Bufo regularis* Complex because of the acoustical similarities between the mating call of *Bufo tuberosus* and species of that complex. The ratio of tympanum diameter/parotoid width separates *B. amieti* from almost all congeners. Tympanum diameter, snout-urostyle length or parotoid length/parotoid width distinguish it from the others. Tympanum distinct, its horizontal diameter approximately 0.12 the width of the head and 0.18 the width of the parotoid; snout-urostyle length about 37mm; parotoid length 1.7 times the parotoid width; no tarsal fold; male unknown; first finger longer than second; toes not extensively webbed ($3\frac{3}{4}$ phalanges of fourth toe free of webbing on both inner and outer margins); lacking series of warts on posterior surface of forearm; large warts with multiple cornified spinules extensively developed. Ecological data for two localities: lowland rain forest, altitude.

\bar{x} = 136.5m, range (123-150); mean annual rainfall,

\bar{x} = 173.70cm (161.1-186.3); mean annual temperature, \bar{x} = 23.95°C (23.9-24)(Table 4).

DESCRIPTION

Holotype: Snout-urostyle length (SU) 37.7mm; form moderately stout; head triangular, broader than long, head width (HW) 15.5mm, head length (HL) 10.2mm; snout obtusely rounded; nostrils closer to tip of snout than to eye; canthus rostralis

<i>n</i>	Snout-urostyle width	Head width	Head length	Tympanum diameter	Eye diameter	Paratoid length	Paratoid width	Urostyle-beel	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/UH
<i>Biffo villiersi</i>																	
Cameroun																	
7	63.97	22.83	12.44	3.27	6.04	13.93	6.16	49.90	2.806	1.842	0.142	2.284	1.653	0.236	3.727	0.363	1.287
	52.3	19.1	10.5	1.9	5.3	12.5	4.9	38.4	2.56	1.71	0.10	1.92	1.49	0.15	3.24	0.21	1.20
	69.0	26.0	15.0	4.0	7.0	15.2	7.2	56.1	3.07	2.09	0.16	2.62	2.08	0.32	4.00	0.44	1.36
6	54.85	19.28	11.92	2.80	5.90	12.00	4.90	44.87	2.849	1.625	0.146	2.452	1.613	0.235	3.957	0.311	1.234
	54.0	18.0	10.8	2.0	5.1	11.2	4.5	41.0	2.68	1.52	0.10	2.30	1.46	0.17	3.45	0.22	1.00
	56.5	20.5	13.5	3.5	6.5	13.0	5.5	55.0	3.06	1.80	0.18	2.60	1.78	0.31	4.56	0.39	1.34
<i>Biffo danielclae</i>																	
Monogaga, Côte d'Ivoire																	
3	44.6	16.4	11.1	2.4	5.4	11.3	5.0	32.9	2.723	1.480	0.144	2.241	1.462	0.211	3.266	0.473	1.356
	42.9	15.6	9.9	2.1	5.2	10.3	4.8	30.6	2.70	1.32	0.13	2.13	1.36	0.18	2.89	0.39	1.31
	46.8	17.2	11.8	2.5	5.6	12.0	5.4	34.4	2.75	1.65	0.15	2.45	1.67	0.24	3.58	0.52	1.40
22	37.78	13.68	9.94	2.18	4.77	8.04	3.63	29.23	2.765	1.379	0.159	2.220	1.729	0.276	3.784	0.603	1.293
	0.593	0.239	0.176	0.048	0.081	0.263	0.083	0.372	0.0155	0.0183	0.0027	0.0634	0.0474	0.0089	0.0616	0.0141	0.0127
	32.0	11.5	8.6	1.7	4.1	5.9	3.0	26.1	2.66	1.20	0.13	1.73	1.31	0.19	3.31	0.48	1.21
	44.4	16.5	11.5	2.6	5.9	10.7	4.6	33.7	2.92	1.57	0.19	2.86	2.14	0.36	4.48	0.72	1.45
<i>Biffo camerunensis</i>																	
Cameroun, Nigeria, République du Congo																	
13	66.89	27.08	15.81	4.72	7.11	14.67	5.25	54.83	2.472	1.729	0.174	2.890	1.866	0.324	5.372	0.934	1.236
	1.311	0.526	0.529	0.136	0.187	0.487	0.336	1.089	0.0263	0.0482	0.0034	0.1451	0.0627	0.0116	0.2915	0.0542	0.0163
	58.3	24.0	12.8	3.4	6.2	12.8	3.5	48.2	2.31	1.52	0.14	2.03	1.49	0.26	3.51	0.60	1.18
	74.1	30.1	18.4	5.4	8.4	18.4	7.8	63.0	2.61	2.02	0.19	3.74	2.35	0.41	7.17	1.34	1.30
Cameroun & Rio Muni, Guinea Ecuatorial																	
14	48.48	18.71	11.13	3.50	5.33	10.17	3.67	42.01	2.594	1.712	0.188	2.799	1.855	0.348	5.150	0.966	1.155
	1.081	0.455	0.531	0.072	0.112	0.333	0.145	0.935	0.0177	0.0600	0.0037	0.0998	0.0504	0.0120	0.1477	0.0301	0.0118
	42.0	16.3	8.9	3.0	4.8	7.8	3.0	34.7	2.50	1.29	0.16	2.17	1.48	0.26	4.19	0.67	1.07
	55.2	21.8	15.8	4.0	6.0	12.4	5.2	46.3	2.75	1.98	0.21	3.35	2.10	0.42	5.82	1.13	1.26
<i>Biffo camerunensis</i>																	
Côte d'Ivoire, Ghana, Guinée, Liberia																	
8	71.16	28.79	16.46	4.19	7.63	17.46	4.76	54.71	2.476	1.792	0.146	3.756	1.656	0.241	6.240	0.917	1.289
	61.9	25.0	13.2	3.1	6.9	15.1	3.3	50.2	2.34	1.39	0.12	2.84	1.47	0.20	4.55	0.67	1.17
	83.1	34.4	22.8	4.9	9.8	20.0	6.0	66.3	2.60	2.14	0.17	4.76	1.89	0.30	8.64	1.36	1.48

	n	Snout-urostyle	Head width	Head length	Tympanum diameter	Eye diameter	Paratoid length	Paratoid width	Urostyle-heel	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/HL
<i>Bufo camerunensis</i>																		
Ghana, Liberia, Sierra Leone																		
Mean - males	4	56.15	21.45	13.73	3.73	6.20	13.05	4.40	43.68	2.625	1.567	0.173	2.946	1.705	0.295	4.955	0.858	1.28
Minimum		53.0	19.7	12.7	3.3	5.4	9.7	3.4	40.4	2.37	1.49	0.17	2.52	1.35	0.24	4.48	0.75	1.21
Maximum		61.3	23.5	15.8	4.1	7.0	17.4	4.9	46.9	2.79	1.65	0.18	3.55	2.12	0.36	6.06	1.03	1.35
<i>Bufo camerunensis</i>																		
République Démocratique du Congo																		
female	1	69.5	30.3	17.7	5.6	7.4	16.8	5.9	55.6	2.29	1.71	0.18	2.85	1.80	0.33	5.14	0.95	1.25
<i>Bufo camerunensis</i>																		
République Démocratique du Congo																		
Mean - males	6	53.20	21.28	14.68	4.27	6.13	11.35	4.50	46.43	2.503	1.463	0.200	2.582	1.947	0.387	5.016	0.995	1.147
Minimum		45.4	18.2	10.9	3.2	5.1	6.7	2.5	39.0	2.39	1.34	0.18	1.90	1.64	0.29	3.62	0.72	1.11
Maximum		55.7	23.3	17.0	5.0	6.8	13.9	5.8	50.0	2.60	1.67	0.23	3.28	2.72	0.48	7.28	1.28	1.18
<i>Bufo latifrons</i>																		
Cameroun & Rio Muni, Guinée Equatoriale																		
Mean - females	4	69.08	24.63	15.98	2.85	7.20	10.80	3.93	58.60	2.808	1.545	0.115	2.930	2.304	0.265	6.596	0.762	1.181
Minimum		66.2	22.8	15.1	2.5	6.8	9.3	2.8	54.3	2.75	1.46	0.11	1.72	2.01	0.24	4.54	0.50	1.12
Maximum		71.3	25.9	17.7	3.2	7.5	12.6	5.4	63.8	2.90	1.62	0.12	3.60	2.63	0.29	8.14	0.89	1.22
<i>Bufo latifrons</i>																		
Cameroun																		
Mean - males	23	49.42	18.84	11.77	2.12	5.93	8.04	3.19	42.37	2.629	1.613	0.113	2.683	2.367	0.265	6.213	0.709	1.168
Standard Error		0.850	0.326	0.271	0.072	0.148	0.193	0.147	0.736	0.0366	0.0349	0.0036	0.1901	0.0612	0.0081	0.3403	0.0539	0.0122
Minimum		39.7	15.3	9.3	1.5	4.4	6.5	1.4	34.2	2.05	1.31	0.08	1.86	1.99	0.19	4.09	0.43	0.98
Maximum		55.7	21.1	14.0	2.8	7.1	10.5	4.4	47.5	2.90	1.98	0.14	6.00	3.08	0.32	12.00	1.57	1.25
<i>Bufo togoensis</i>																		
Togo																		
Mean - females	4.0	68.33	27.18	15.25	3.50	7.90	18.85	5.28	54.63	2.515	1.785	0.129	3.728	1.452	0.188	5.486	0.720	1.251
Minimum		61.8	24.7	14.4	3.1	6.7	17.2	4.2	53.1	2.38	1.65	0.11	2.81	1.28	0.14	3.60	0.40	1.15
Maximum		71.9	28.7	16.7	3.9	8.9	21.6	7.7	56.1	2.61	1.90	0.14	4.33	1.67	0.23	6.83	0.93	1.34
Mean - males	8.0	51.58	19.49	12.36	2.53	6.36	11.94	3.68	43.86	2.647	1.579	0.130	3.365	1.648	0.215	5.488	0.715	1.179
Minimum		47.3	18.1	11.4	2.3	5.3	9.7	2.6	39.1	2.58	1.44	0.12	2.47	1.47	0.17	4.21	0.52	1.10
Maximum		56.3	21.5	13.2	2.8	7.6	13.7	4.8	46.9	2.73	1.73	0.14	4.73	2.04	0.29	7.62	1.08	1.33

n	Snout-urostyle width	Head length	Tympanum diameter	Eye diameter	Paratoid length	Paratoid width	Urostyle-heel	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/UH
<i>Bufo maculatus</i>																
Monrovia, Liberia																
10	60.62	21.86	12.71	3.95	6.21	12.58	6.52	2.776	1.743	0.181	2.247	1.759	0.315	3.917	0.709	1.285
	1.112	0.455	0.563	0.150	0.115	0.504	1.167	0.703	0.0654	0.0061	0.2158	0.0704	0.0079	0.3713	0.0714	0.0213
	55.8	19.9	10.3	3.2	5.6	10.0	4.0	44.5	1.46	0.15	0.76	1.54	0.28	1.34	0.23	1.20
	67.2	24.0	15.8	4.6	6.8	15.1	16.3	50.8	1.95	0.21	2.91	2.16	0.36	5.40	0.96	1.42
10	52.53	19.30	10.36	3.09	5.90	10.36	4.59	40.64	1.865	0.160	2.290	1.904	0.308	4.275	0.683	1.293
	1.282	0.526	0.287	0.131	0.155	0.589	0.238	0.828	0.0305	0.0049	0.1463	0.0993	0.0237	0.1918	0.0341	0.0232
	45.4	16.1	8.9	2.4	5.3	8.0	3.9	37.0	1.73	0.14	1.84	1.54	0.22	3.37	0.48	1.23
	58.0	21.2	12.0	3.7	6.7	13.8	6.3	43.8	2.01	0.18	3.26	2.59	0.46	5.31	0.86	1.46
<i>Bufo superciliaris</i>																
Cameroun & République Démocratique du Congo																
10	128.23	51.07	24.69	5.61	12.72	38.77	13.20	100.69	2.511	0.110	2.982	1.329	0.146	3.970	0.438	1.283
	3.133	0.891	0.921	0.214	0.275	1.255	0.636	3.561	0.0423	0.0037	0.1266	0.0473	0.0065	0.2427	0.0330	0.0404
	117.4	47.6	21.1	4.7	11.0	32.3	9.3	86.0	2.30	0.09	2.39	1.16	0.12	3.21	0.31	1.07
	147.0	56.1	30.8	6.7	13.6	46.1	15.4	125.9	2.72	0.12	3.47	1.56	0.18	5.37	0.63	1.47
République Démocratique du Congo																
10	114.25	46.12	22.29	5.51	10.67	33.06	11.72	88.08	2.492	0.121	2.829	1.404	0.168	3.950	0.475	1.297
	1.801	1.380	0.815	0.204	0.553	0.960	0.362	1.149	0.0647	0.0752	0.0067	0.0725	0.0514	0.1094	0.0248	0.0132
	108.0	41.7	19.3	4.7	8.4	26.7	10.4	83.7	1.98	0.09	2.50	1.19	0.14	3.35	0.38	1.25
	127.5	56.8	26.5	6.6	13.3	38.0	14.0	94.6	2.72	0.15	3.17	1.69	0.22	4.58	0.63	1.37
<i>Bufo regularis</i>																
Ogbomoshos, Nigeria																
30	89.91	35.46	20.65	6.89	9.63	24.75	8.05	69.18	2.536	0.178	3.088	1.442	0.278	4.437	0.861	1.301
	2.451	0.955	0.503	0.351	0.193	1.035	0.281	1.848	0.0221	0.0257	0.0082	0.1256	0.0290	0.0087	0.1545	0.0184
	74.6	29.4	18.2	5.1	8.2	19.3	7.0	58.0	2.41	0.162	0.17	2.50	0.31	3.72	0.68	1.21
	98.0	38.1	22.6	8.4	10.7	28.8	9.6	75.1	2.62	0.187	0.23	3.65	0.33	5.25	1.17	1.41
30	81.13	31.87	19.44	5.91	9.23	21.54	6.48	61.58	2.550	0.1640	0.185	3.371	1.486	4.988	0.926	1.321
	1.186	0.640	0.345	0.166	0.120	0.635	0.296	1.474	0.0327	0.0240	0.0031	0.1469	0.0310	0.0078	0.1919	0.0429
	76.7	28.8	17.8	5.0	8.8	19.1	5.3	54.5	2.43	0.151	0.16	2.50	1.34	3.96	0.73	1.18
	88.2	35.5	21.5	6.8	9.8	24.8	8.0	70.6	2.74	0.174	0.20	4.03	1.64	5.81	1.13	1.41

	n	Snout-urostyle width	Head length	Tympanum diameter	Eye diameter	Paratoid length	Paratoid width	Urostyle-heel	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/UH
<i>Bufo veros</i>																	
N'djamena, Chad																	
Mean - females	5	69.03	14.2	4.43	7.37	15.25	5.85	47.67	2.861	1.710	0.184	2.625	1.583	0.291	4.153	0.762	1.452
Minimum		67.6	12.9	4.3	6.9	14.8	5.1	43.0	2.8	1.54	0.18	2.34	1.53	0.27	3.77	0.67	1.33
Maximum		73.6	15.7	4.6	7.6	15.8	6.4	52.0	3.03	1.85	0.20	3.02	1.62	0.31	4.82	0.88	1.57
Mean - males	10	71	25.37	15.14	4.32	7.5	6.23	50.41	2.801	1.692	0.170	2.675	1.544	0.263	4.121	0.702	1.413
Standard Error		1.409	0.570	0.118	0.303	0.681	0.290	1.371	0.0252	0.0577	0.0040	0.0745	0.0472	0.0103	0.1361	0.0261	0.0278
Minimum		60.5	21.9	3.5	5.6	13.5	5.2	42.5	2.69	1.39	0.15	2.21	1.31	0.21	3.38	0.55	1.27
Maximum		75.9	27.2	4.8	8.8	20.1	7.8	56.8	2.99	2.10	0.19	3.08	1.87	0.31	4.87	0.81	1.53
<i>Bufo pentoni</i>																	
Senegal																	
Mean - females	10	55.42	20.28	9.44	3.57	6.07	11.8	5.55	40.67	2.735	2.164	0.176	2.159	1.728	3.719	0.655	1.368
Standard Error		0.907	0.361	0.300	0.118	0.099	0.339	1.228	0.0328	0.0649	0.0054	0.1030	0.0466	0.0080	0.1850	0.0375	0.0217
Minimum		50.0	18.4	8.1	3.1	5.5	9.9	4.7	34.1	2.59	1.87	1.41	1.48	0.27	2.71	0.47	1.25
Maximum		59.4	21.6	10.8	4.2	6.6	13.2	7.0	47.4	2.91	2.45	0.21	2.54	1.92	4.51	0.81	1.51
Mean - males	10	53.31	19.78	9.39	3.58	6	11.33	4.29	39.54	2.696	2.113	0.181	2.657	1.758	4.625	0.837	1.353
Standard Error		0.982	0.337	0.192	0.121	0.158	0.308	1.103	0.989	0.0313	0.0485	0.0068	0.1026	0.0576	0.0142	0.0946	0.0301
Minimum		47.8	17.8	8.5	2.7	5.1	9.9	4.0	33.6	2.50	1.88	0.14	2.06	1.52	4.04	0.66	1.23
Maximum		60.1	21.7	10.4	4.1	6.8	12.9	4.9	45.4	2.85	2.35	0.21	3.15	1.98	4.98	1.00	1.57

TABLE 2. Apparent diagnostic differences between linear morphological characters of adult females of *Bufo amieti* and species of *Bufo* from west and central Africa and those all species of the *B. regularis* Complex. * species known from west of the Dahomey Gap. These comparisons are tentative because of the small sample size for *B. amieti* (n=2). A difference (+) indicates that ranges of variation do not overlap. These comparisons cannot be tested for statistical significance because of the small sample size for *B. amieti* and a few of the other species. For data on other species, see Table 7 in Largen *et al.* (1978), Table 12 in Tandy *et al.* (1982) and Tables 1, 9 and 16 in Tandy & Feener (1985).

Species Sex	SU	HW	HL	T	E	PL	PW	UH	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/UH	Diagnostic	Not diagnostic
Females																			
<i>B. tuberosus</i>	+	+	+	+	+			+						+	+		+	8	9
<i>B. gracillipes</i>				+							+			+	+	+		7	10
<i>B. villiersi</i>	+	+	+	+	+	+		+		+		+		+	+	+		12	5
<i>B. regularis</i> *	+	+	+	+	+	+		+			+	+		+	+	+		11	6
<i>B. superciliaris</i>	+	+	+	+	+	+	+	+	+		+		+	+	+	+		14	3
<i>B. garmani</i>	+	+	+	+	+	+	+	+			+	+		+	+	+		11	6
<i>B. latifrons</i>	+	+	+	+	+	+		+					+	+	+	+		11	6
<i>B. togoensis</i> *	+	+	+	+	+	+		+		+	+			+	+	+		12	5
<i>B. brauni</i>	+	+	+	+	+	+		+		+	+			+	+	+		14	3
<i>B. gutturalis</i>	+	+	+	+	+	+		+		+	+			+	+	+		11	6
<i>B. kisolensis</i>	+	+	+	+	+	+	+	+		+	+				+			12	5
<i>B. poweri</i>	+	+	+	+	+	+	+	+		+	+			+	+	+		14	3
<i>B. rangeri</i>	+	+	+	+	+	+		+			+	+			+	+		10	7
<i>B. camerunensis</i> *	+	+	+	+	+	+		+			+	+		+	+	+	+	13	4
<i>B. kerinyagae</i>	+	+			+	+		+			+			+				7	10
<i>B. xeros</i> *	+	+	+	+	+	+		+			+	+		+	+	+		12	5
<i>B. asmarae</i>	+	+	+	+	+	+		+		+	+			+	+	+		12	5
<i>B. maculatus</i> *	+	+	+	+	+	+		+			+	+	+	+	+	+		13	4
<i>B. danielae</i> *	+	+		+	+	+		+			+	+			+			9	8
<i>B. blanfordi</i>			+		+			+							+	+		5	12
<i>B. langanoensis</i>											+	+		+	+	+		6	11
<i>B. turkanae</i>	+	+	+	+	+		+	+			+	+	+	+	+	+		13	4
<i>B. perreti</i>	+	+	+	+	+	+		+		+	+	+	+	+	+	+		13	4
<i>B. steindachneri</i>				+					+		+	+	+	+	+	+		8	9
<i>B. pentonii</i> *																			
- Senegal	+	+		+	+	+		+		+	+			+		+		10	7

sharp; horizontal diameter of eye greater than length of snout; tympanum distinct, vertically oval, its horizontal diameter 43% that of the eye, 12% that of head width, tympanum diameter (T) 1.8mm, eye diameter (E) 4.1mm; parotoid glands enormous in relation to body size, globose, 1.6 times longer than wide, (PL/PW 1.60), narrowly separated from the eye, the anterior edges lying between the anterior and posterior borders of the tympanum, parotoid length (PL) 9.6mm, 26% of snout-urostyle length, parotoid width (PW) 6.0mm, 63% of parotoid length.

First finger longer than second, second longer than fourth; fingers lacking marginal folds; subarticular tubercles large, undivided; palm with numerous tubercles lacking spinules; inner metacarpal tubercle moderately developed but much smaller than outer metacarpal tubercle and lacking spinules; lacking any series of distinct warts on the posterior surface of the forearm; toes moderately webbed; toe IV with almost four phalanges free of webbing on both the inner and outer margins; most toes

TABLE 3. Variation of nonlinear morphological characters in species of *Bufo* from west and central Africa. * species known from west of the Dahomey Gap. RF - red color on femoral skin. RF - red color on femoral skin. DP - distinct parotoid glands. TF - tarsal fold. WS - white spots on dorsal or lateral skin. VM - ventral mottling. For data on other species, see Table 7 in Largen et al. (1978) and Table 12 in Tandy et al. (1982). (1) very few specimens have red femoral color, (2) red on femur in females only; (3) tarsal fold sometimes broken into warts.

Species	n males	n females	Total	Sexual dimorphism in gular color	Vocal sac openings in male: absent right	Vocal sac openings in male: absent left	RF	DP	TF	WS present	VM absent	VM +	(+)
<i>Bufo anitetti</i> * - Côte d'Ivoire	0	2	2	? ? ?	? ? ?	?	-	+	-	1	1	2	0
<i>Bufo tuberosus</i> - Cameroun, République Démocratique du Congo	8	30	38	absent	2	3	-(1)	+	-	7	31	36	0
<i>Bufo gracilipes</i>	10	10	20	present	0	1	-	weak	-	1	19	17	3
<i>Bufo villiersi</i>	6	4	10	absent	0	0	-	weak?	-	0	8	0	8
<i>Bufo danielae</i> * - Monogaga, Côte d'Ivoire	22	3	25	present	0	11	-	weak	+	14	11	25	0
<i>Bufo camerunensis</i> * - Cameroun, Côte d'Ivoire, Ghana, Rio Muni-Ecuatorial, Guinée, Libéria, République du Congo, Sierra Leone	17	18	35	present	0	0	17	+(2)	+	+(3)	1	34	17
<i>Bufo latifrons</i> - Cameroun & Rio Muni, Guinée Ecuatorial	22	4	26	present	0	0	0	+	+	1	21	15	6
<i>Bufo togoensis</i> * - Togo	6	3	9	present	0	0	6	+	+(3)	1	4	4	1
<i>Bufo maculatus</i> *	41	33	74	present	0	18	20	3	+	16	57	31	30
<i>Bufo superciliaris</i> * - Cameroun & République Démocratique du Congo	10	10	20	absent	10	0	0	+	+	8	12	18	0
<i>Bufo regularis</i> *	127	55	182	present	0	0	1	126	-(1)	+	85	97	78
<i>Bufo xeros</i> *	20	12	32	present	0	0	1	19	+	+	1	31	0
<i>Bufo pentoni</i> * - Senegal	10	10	20	absent	0	5	4	1	-	weak	+	0	20

with only a slight margin of webbing at the base; webbing with small melanized spinules on the dorsal surface; tubercles of soles smaller than those of palms; inner and outer metatarsal tubercles prominent and suited for burrowing, the inner larger and more raised than the outer. No tarsal fold. Urostyle-heel length (UH) 26.5mm. Dorsum with numerous conical and rounded warts, each with one or more large spinules and some smaller spinules; spinules extending over entire dorsum, including surfaces of parotoid glands, but less numerous anterior to eyes. Venter with somewhat smaller warts with spinules similar to those of the dorsum. Warts at rictus partially fused and covered with numerous small spinules.

Ovaries with immature eggs. The specimen was apparently collected outside of the breeding season.

Color (in alcohol) disruptively patterned light and dark brown; Dorsal background color light brown; four pairs of bilateral reticulate dark brown markings. No *B. regularis*-like white spots on dorsum; No vertebral line; Parotoids and rictal warts same color as dorsum; Dark melanized spinules prominent against lighter background. Lower margin of orbit and part of area beneath eye cream. Upper surfaces of limbs with well defined brown cross bars sometimes outlined in darker brown; posterior femoral integument light brown. Venter markedly reticulately mottled brown and cream. See Figs. 1 - 2.

Paratype: The paratype female is similar to the holotype (Table 1). It is slightly smaller- SU 35.9mm, but is gravid and thus indicates that the breeding season includes December near the beginning of the long dry season. Coloration is like the holotype except overall a somewhat darker brown, and it has a few *B. regularis*-like white spots on the dorsum. See Figs. 3-4.

GEOGRAPHIC DISTRIBUTION AND ECOLOGY

B. amieti is known from only two localities in lowland rainforest of western Côte-d'Ivoire (Fig. 5). Statistics on the altitude, rainfall and temperature of these localities are given in the diagnosis and in Table 4.

The small number of known localities for *B. amieti* precludes statistical comparisons of ecological variables with other species. Data in Table 4 and 5 indicate some differences and similarities. *B. amieti* seems to differ in one or more ecological characteristics from eighteen of the 25 species with which it has been compared (Table 5), and it is unlikely to be sympatric with any of those. Of the remaining seven species, four, *B. regularis*, *B. superciliaris*, *B. camerunensis* and *B. maculatus*, are known from west Africa west of the Dahomey Gap, but *B. amieti* has not yet been found syntopic with any other bufonid species. *Bufo cristiglans* Inger & Menzies, 1961, is considered a synonym of *B. camerunensis* Parker, 1936.

If *B. amieti* is restricted to relatively undisturbed lowland rainforest, it is unlikely to occur in the same local areas as *B. regularis* or *B. maculatus*. But such a preference for high forest would make it more likely to occur with *B. superciliaris* or *B. camerunensis*. If *B. amieti* does occur locally with these species, it would probably avoid them because the small size of *B. amieti* would make it likely food fare for the other two species.

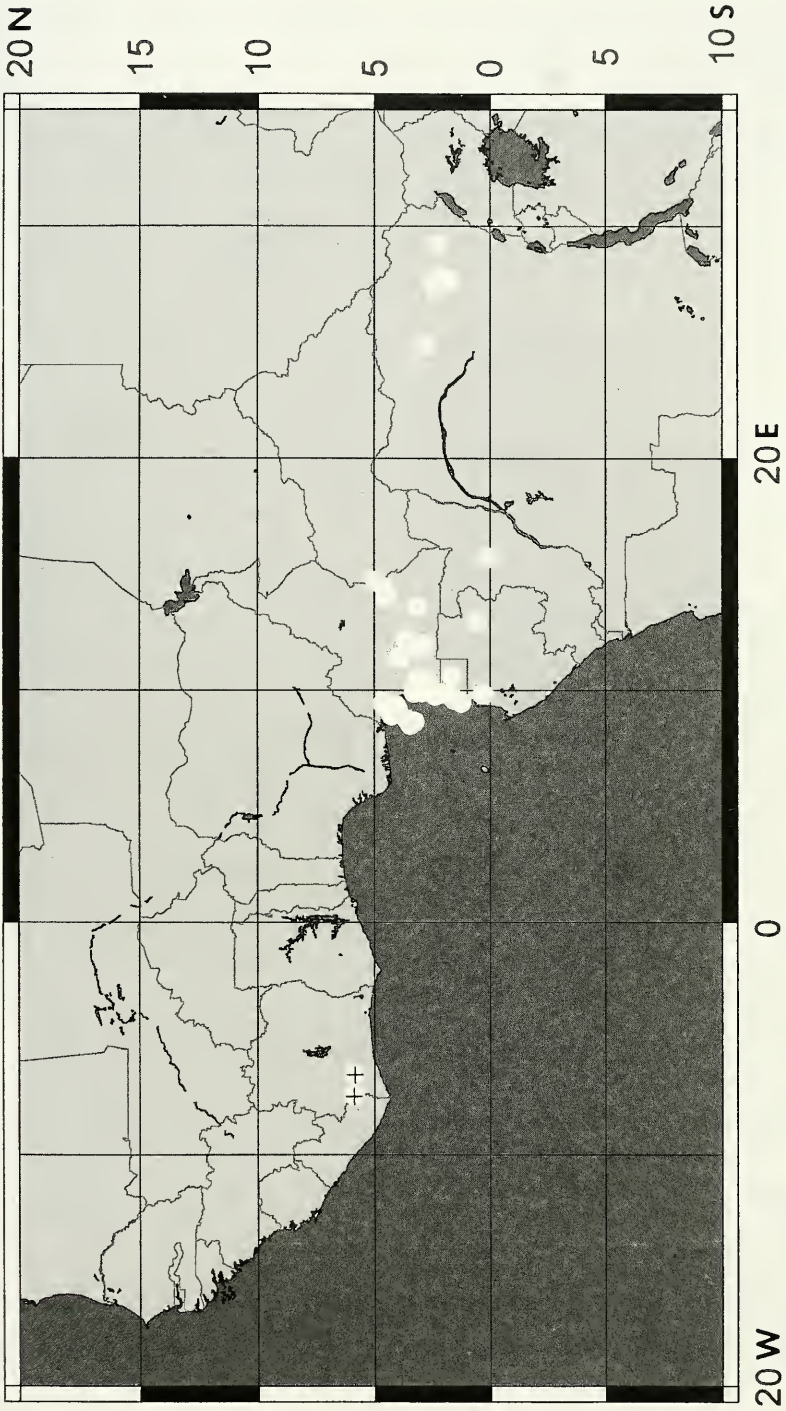


FIG. 5. Known geographic distribution of *Bufo amietii* and *B. tuberosus*. Circles with cross = *B. amietii* sp. n. open circles = *B. tuberosus*.

TABLE 4. Ecological characteristics of *Bufo amieti* and other species of *Bufo* that are known to occur in west or central Africa. Accuracies and sources of these data vary. Some figures are based on surveys or meteorological stations near the locality. Others were interpolated from map contours, isotherms or isohyets. One decimal point given does not necessarily imply such accuracy of measurement but rather that these were the figures used to compute the statistics. Individual values for some altitudes may be in error by 50m or more. Most basic data are from Bartholomew (1985), Knoch & Schulze (1956), NIMA (1999), Wernstedt (1959, 1972) or Survey of Kenya (1962).

	n	Elevation meters	Mean Annual Temp oC	Mean Annual Rainfall cm
<i>Bufo amieti</i>				
Côte d'Ivoire				
Grabazouo		150	23.9	161.1
Tai		123	24	186.3
Mean	2	136.5	23.95	173.7
<i>Bufo tuberosus</i>				
Cameroun, Gabon, Guinea Ecuatorial, République Centrafricaine, République du Congo, République Démocratique du Congo				
Mean		412.8	23.69	224.87
Standard Error		46.63	0.316	20.472
Minimum		10	22	150
Maximum		1266	26.4	411.8
n		48	14	15
<i>Bufo danielae</i>				
Côte d'Ivoire				
Monogaga	1	10	25	150
<i>Bufo camerunensis</i>				
Cameroun, Gabon, Nigeria, République du Congo & République Démocratique du Congo				
Mean	10	526.9	23.1	184.4
Standard Error		95.49	0.49	13.92
Minimum		100	20	140
Maximum		1066.8	24.7	290
<i>Bufo togoensis</i>				
Togo				
Mean	3	447.3	22.8	141
Minimum		350	22.8	139.7
Maximum		589.8	22.8	142.3
n		3	1	2
<i>Bufo latifrons</i>				
Cameroun & Guinea Ecuatorial				
Mean	5	549.7	24.1	250.9
Minimum		50	22.4	145.3
Maximum		876.9	25.2	350
<i>Bufo maculatus</i>				
Angola, Bissao, Cameroun, Ethiopia, Kenya, Liberia, Mozambique, République Centrafricaine, South Africa, Zimbabwe				
Mean	10	480.5	23.1	163.4
Standard Error		206.62	1.09	44.4
Minimum		19.5	26.7	491.2
<i>Bufo superciliaris</i>				
Cameroun, Ghana, République Démocratique du Congo				
Mean	10	561.1	22.9	193.9
Standard Error		113.59	0.55	13.12
Minimum		50	20	150
Maximum		1066.8	26	260

	n	Elevation meters	Mean Annual Temp oC	Mean Annual Rainfall cm
<i>Bufo regularis</i>				
Algeria, Angola, Cameroun, Egypt, Ethiopia, Gabon, Kenya, Libya, Nigeria, République Centrafricaine, République Démocratique du Congo, Senegal, Sudan, Uganda				
Mean	67	793.6	21.77	102.67
Standard Error		81.16	0.453	8.373
Minimum		7	14	0.3
Maximum		2500	29.6	280
<i>Bufo xeros</i>				
Chad, Ethiopia, Kenya, Uganda				
Mean	10	802.6	23.4	57.8
Standard Error		164.72	1.41	7.8
Minimum		54.9	16	29.9
Maximum		1676.4	29.2	100
<i>Bufo pentoni</i>				
Haute Volta, Senegal, Sudan				
Mean	4	131.5	27.7	40.8
Minimum		5	25	14.9
Maximum		450	29	70
<i>Bufo gracilipes</i>				
Cameroun, Gabon, Guinea Ecuatorial, République du Congo				
Mean	10	310.81	25.52	214
Standard Error		97.57163	0.345704	19.95348
Minimum		10	23	166.4
Maximum		780	27	350
<i>Bufo villiersi</i>				
Cameroun				
Mean	7	1853.5	23.38	263.62
Minimum		1398	22.0	187.7
Maximum		2500	25.0	305.0

B. xeros and *B. pentoni* occur in much drier habitats in the northern portion of West Africa.

B. danielae is known from only two coastal sites in Côte-d'Ivoire (Perret, 1977) which are at lower elevation and appear to have somewhat warmer and drier climates than do the known localities of *B. amieti*.

B. togoensis is known from only three localities that are at higher elevations with somewhat cooler temperatures and lower rainfall than the known sites for *B. amieti*. Tandy (1972) considered *B. togoensis* to be a synonym of *B. latifrons*. Additional recent collections indicate that *B. togoensis* is a distinct species resembling *B. latifrons* in the size and proportions of its tympani and

B. camerunensis in the structure of its parotoid glands.

The ecological features of *B. tuberosus* localities in central Africa do not appear to differ from *B. amieti* sites.

The similarities of both morphology and ecology indicate a close relationship between *B. amieti* and *B. tuberosus*. Apparently *B. amieti* is a western isolate derived from a common ancestor of the two species. This pattern is similar to that of several pairs of lowland rainforest hyperoliid treefrog species east and west of the V-Baoulé

TABLE 5. Apparent differences and similarities between the ecological characteristics of *Bufo amieti* and species of *Bufo* from west or central Africa and those of all species of the *B. regularis* Complex. * species known from west of the Dahomey Gap. These comparisons are tentative because of the small number of known localities for *B. amieti* (n=2). A difference (+) indicates that ranges of variation do not overlap. These comparisons cannot be tested for statistical significance because of the small sample size for *B. amieti* and a few of the other species. (1) - species for which number of localities is less than 10. For data on other species, see Tables 3 in Tandy *et al.* (1976) and Tandy *et al.* (1982), Table 8 in Tandy *et al.* (1985), and Table 13 in Tandy & Feener (1985).

Species compared	Elevation	Mean Annual Temperature	Mean Annual Rainfall	Different	Similar
<i>B. tuberosus</i>	-	-	-	0	3
<i>B. gracilipes</i>	-	-	-	0	3
<i>B. villiersi</i> (1)	+	-	+	2	1
<i>B. regularis</i> *	-	-	-	0	3
<i>B. superciliaris</i> *	-	-	-	0	3
<i>B. garmani</i>	-	-	+	1	2
<i>B. latifrons</i> (1)	-	-	-	0	3
<i>B. togoensis</i> *(1)	+	+	+	3	0
<i>B. brauni</i> (1)	+	+	+	3	0
<i>B. gutturalis</i>	-	-	+	1	2
<i>B. kisoloensis</i>	+	+	-	2	1
<i>B. poweri</i>	+	+	+	3	0
<i>B. rangeri</i>	-	+	-	1	2
<i>B. camerunensis</i> *	-	-	-	0	3
<i>B. kerinyagae</i>	+	+	-	2	1
<i>B. xeros</i> *	-	-	+	1	2
<i>B. asmarae</i>	+	-	+	2	1
<i>B. maculatus</i> *	-	-	-	0	3
<i>B. danielae</i> * (1)	+	+	+	3	0
<i>B. blanfordi</i>	+	-	+	2	1
<i>B. langanoensis</i> (1)	+	+	+	3	0
<i>B. turkanae</i> (1)	+	+	+	3	0
<i>B. perreti</i> (1)	+	+	-	2	1
<i>B. steindachneri</i>	-	-	+	1	2
<i>B. pentoni</i> * - Senegal (1)	-	+	+	2	1

ecological break of Côte-d'Ivoire as described by Schiøtz (1967) for *Hyperolius sylvaticus ivoiriensis* vs *H. s. sylvaticus*, *Leptopelis macrotis* vs *L. rufus* (erroneously as "*L. palmatus*" (Perret, 1973)) and *Leptopelis occidentalis* vs *L. boulengeri*. The initial evolutionary barrier to eastern and western isolates probably is related to changes in Africa's climate during geologic time and particularly to interpluvial periods when the rainforest blocks were probably most isolated.

Bufo tuberosus Günther, 1858

Bufo tuberosus Günther, 1858: 60, pl. 3, fig. C, 140. Peters, 1875: 202. Boulenger, 1880: 546-547, 564, 572-573; 1882: 304. Rochebrune, 1884: 20, 47-49, Pl. IV, Fig. 2. Boulenger, 1887: 565. Bocage, 1895: 15, 272. Werner, 1898: 202. Mocquard, 1903: 215. Boulenger, 1900: 435; 1903: 62. Bocage, 1903: 45. Boulenger, 1906: 158. Johnston, 1908: 950. Nieden, 1908: 509-510, 517. Muller, 1910: 625. Nieden, 1910: 66, 68, Fig 147. Barbour, 1911: 135. Lampe, 1911: 220. Arldt, 1917: 123. Noble, 1922: 39. Nieden, 1923:104. Noble, 1924: 167, 177-178, 311. De Witte, 1930: 241-242, 252; 1934: 167. Loveridge, 1936: 84. Parker, 1936: 155. Mertens, 1938:10; 1941: 277. Monard, 1951: 174. Curry Lindahl, 1956: 56. Perret & Mertens, 1957: 555, 557. Guibé & Lamotte, 1958: 243. Inger & Menzies, 1961: 594.

Mertens, 1965: 14.19. Oates, 1965:89. Perret, 1966: 309-311, 314-315. Amiet & Perret, 1969: 120. Perret, 1971: 131. Perret & Amiet, 1971: 48, 50, 52-53. Amiet, 1973: 136; 1975: 46, 50, 54, 56 (photo); 1976: 150-152 (sonagram); 1978:199. Frost, 1985:63. Amiet, 1989: 92, 95, 98-99 (Pl. I - photo). Brauer, 1991:6, 159, 179.

Bufo polycerus Werner, 1897: 211. Nieden, 1923: 105.

CAMEROUN - Akak-Yemefek; 2°37'N 10°04'E, alt. 50m; ♀ MHNG917.67; 15.V.1955; J.-L. Perret. Batouri; 4°35'N 14°24'E, alt. 655m; ♂ BM1934.12.1.14; IV.1933; M. Merfield. Bibundi (Bibunde); 4°13'N 8°59'E, alt. 50m; (Lampe, 1911). Bipindi; 3°06'N 10°30'E, alt. 200m; 1 specimen; Zenker. (Nieden, 1910). Campo; 2°22'N 9°48'E, alt. 10m; ♀ MHNCF148; I.1947; A. Monard. Ebonji; 4°06'N 9°24'E, alt. 50m; "cri de rivalité" sonagram; (Amiet, 1989, p. 151). Efangono (=?"Efangong"); 3°04'N 11°49'E, alt. 750m; ♀ BM1909.7.9.14; 1908?; G. L. Bates. Efulen, Kribi; 2°47'N 10°32'E, alt. 500m; ♂ CNHM3585; Date?; G. L. Bates. ♀ BM1904.10.26.28; 1903?; G. L. Bates. ♀ MHN2482; 1906; Rosenberg. Ekekam III; 3°53'N 11°22'E, alt. 750m; ♂ MHNG1176.5; 10.X.1968. 1 specimen; VI.1968. 3 specimens; X.1968-I.1969. J.-L. Amiet. Foulassi; 2°59'N 11°58'E, alt. 650m; 2 ♂ MHNG1008.30-31; ♀ MHNG917.66; IV.1953; 4 ♀ MHNG1008.27-29, 1020.47; 8 im. MHNG1008.31-37, 1020.48-49; 1960-61; J.-L. Perret. Gadji; 4°29'N 14°03'E, alt. 600m; ♀ BM1937.1.1.21; 1936?; M. Merfield. Idenao; 4°16'N 8°56'E, alt. 100m; 2 ♀ BM1968.470, -508; 12.VIII.1967; T. Struhsaker. Iemonkonn; 3°54'N 11°58'E, alt. 700m; 1 specimen; I-II/1968. J.-L. Amiet. Kala; 3(51'N 11(22'E, alt. 350m; recording of mating call; 12.I.1972; 2 specimens; VII-X.1967; 2 specimens; 15.II-15.IV.1969. J.-L. Amiet. Kendonge (Kidonge), S. Bakundu Forest Reserve; 4°33'N 9°26'E, alt. 50m; ♂ BM1969.1635; ♀ BM1969.509; 1968?; S. Gartlan. Kribi (includes "Dja River" of MCZ record); 2°56'N 9°56'E, alt. 43m; ♀ MCZ2660; 1908; G. H. Schwab. 3 ♀ UMMZ 35611; I-VI.1907; 38320; 1908; 56277; no date; G. H. Schwab. Kumba (=Johann-Albrechtshöhe); 4°38'N 9°25'E, alt. 200m; 2 specimens; Conradt. Nieden, 1910). Limbe (Victoria); 4°01'N 9°12'E, alt. 100m; 4 specimens ZMB?13915; Preuss. (Nieden, 1908, 1910). 32 km N Lolodorf; 3°26'N 10°42'E, alt. 250m; ♂ CAS103353 (TP3545); 21-22.III.1966; T. Papenfuss. Lomié District; 3°09'N 13°35'E, alt. 632m; ♀ BM1937.12.1.54; 1936?; M. Merfield. Mabiogo; 2°12'N 9°53'E, alt. 10m; ♀ MHNCF88; 28.II.1947; A. Monard. Mbanlam; 3°17'N 9°54'E, alt. 612m; ♂ MHNG955.100; 27.IX.1957; J.-L. Perret. Momobelenga; 3°56'N 11°40'E, alt. 600m; ♂ sonagram of mating call; Date?; (Amiet, 1976, p.151). Mundame; 4°35'N, 9°31'E, alt. 100m; 2 specimens; 1906; Rohde. (Müller, 1910). Ngam/Sangmelima; 2°47'N, 11°54'E, alt. 759m; 3 ♀ MHNG955.97-99; 4.I.1957, 3.III.1957, 20.IX.1957; 1 specimen SMF52335; 17.VI.1955; J.-L. Perret. Nkolfe; 3°59'N 11°24'E, alt. 350m; 1 specimen; II.1968; J.-L. Amiet. Nta Ali; 5°33'N 9°30'E, alt. 1266m; ♂; 15.IV.1977; J.-L. Amiet (Amiet, 1978). Rio del Rey; 4°44'N 8°37'E, alt. 50m; 1886?; H. H. Johnston. (Bouleng-er, 1887). Sangmelima (includes "Zima Country" of BM records); 2°56'N 11°59'E, alt. 782m; 2 ♀ BM1906.5.28.150-151; 1905?; G. L. Bates. ♂ CNHM19918; 1899; A. I. Good. nr Ting (32 km S Akonolinga) Sta. 141; 3°40'N 12°10'E, alt. 750m; recording of mating call, ♂ MT.TC.CA123; 7.IV.1971. M. & J. Tandy. Yapoma (nr Douala); 4°02'N 9°49'E, alt. 50m; ♀ ZMB27541; 1910; Schafer. No locality; ♂ ZMB8319; 1870-1880; A. Reichenow.

GABON - Makokou; 0°34'N 12°52'E, alt. 516m; ♂ MHNG2207.33 (MBG1117); 25.X.1964; ♀ MHNG2207.34 (MBG1277); 26.XI.1964; L. P. Knoepfler. Nzing-Ayong (=?"Nzibelong"); 0°18'N, 9°50'E, alt. 50m; 2 ♂ MHNG2207.31-32 (MBG129, 336); ♀ MHNG2207.30 (MBG128); 26.III.1964; L. P. Knoepfler.

GUINEA ECUATORIAL - Bioko (*Fernando Poo*); Basilé (Bassilé), slopes of Pico de Basilé (Santa Isabel); 3°36'N 8°45'E, alt. 527m; 2 adults MB; 1894?; F. Newton. (Bocage, 1895, 1903-1905). Rio Iladyi Falls, south of Bioko (Moca); 3°20'N 8°40'E, alt. 914m; ♀ BM1969.2447; 18.IX.1964; University College Expedition. Luba (Bahia de San Carlos); 3°27'N 8°33'E, alt. 400m; im. SMF?; 20.IX-24.X.1962; R. Mertens. (Mertens, 1965). Moca (Moka); 3°20'N 8°40'E, alt. 914m; ZMB333999; XI.1939; H. Eidmann. (Mertens, 1941). Musola; 3°26'N 8°37'E, alt. 500-800m; (Boulenger, 1905-06). San Antonio de Ureca; 3°16'N 8°39'E, alt. 10m; ♀ ZFMK9291; I.1963; M. Eisentraut. No specific locality; ♀ BM1947.2.21.14(=BM1851-10.25.7) Holotype; 1850; Fraser?

Rio Muni: Cabo San Juan (Cape St. John); 1°15'N 9°30'E, alt. 50m; Martinez de la Escalera. (Boulenger, 1903). Macomo (Makomo); 1°43'N 9°49'E, alt. 350m. (Nieden, 1908). Rio Uoro-Rio Mbini (Rio Benito); 1°34'N 9°38'E, alt. 50m; 4 ♀♀ BM1900.2.17.109-112; 1899; G. L. Bates. Rio Lana 2.4km N Evinayong; 1°39'N 10°39'E, alt. 750m; ♀ BM1965.1412; 6.IX.1965; J. Oates. No locality; ZMB20035; Date?; Collector?

RÉPUBLIQUE DU CONGO (*Congo-Brazzaville*) - Djamba; 0°05'S 15°43'E, alt. 350m; RG3159; XII.1924; H. Schouteden. (De Witte, 1930).

RÉPUBLIQUE DÉMOCRATIQUE DU CONGO (*Belgian Congo; Zaire*) - Bafwabaka; 2°10'N 27°50'E, alt. 750m; ♀ AMNH8405; 1909-1915; Congo Expedition. Buta; 2°47'N 24°47'E, alt. 350m; 2 specimens RG4402-03; II.1925; G. F. De Witte. Epulu; 2°15'N 29°15'E, alt. 350m; 2 specimens; 9.IV.1952. K. Curry-Lindahl. (Curry-Lindahl, 1956). Kifuku (*s/la Nawa*); , alt. ; RG1595; VIII.1925; H. Schouteden. Medje; 2°25'N 27°18'E, alt. 750m; RG1054; IV-V.1910; Lang & Chapin. Medje; 2°25'N 27°30'E, alt. 750m; AMNH8404; IV-V.1910; Congo Expedition. (Noble, 1924). Ngayu; 1°40'N 27°40'E, alt. 750m; AMNH8401-02; IV-V.1910; Congo Expedition. (Noble, 1924). (Note: AMNH8403 is a ♂ *Bufo funereus*.)

RÉPUBLIQUE CENTRAFRICAINE - Tibili (=?"Tuburi, Narob"); 4°58'N 14°42'E, alt. 750m; ♀ BM 1912.1.11.19; 1911?; P. A. Talbot.

MORPHOLOGY

Many aspects of the morphology of *B. tuberosus* have been described and illustrated in the literature. Illustrations include drawings in Günther (1858), Rochebrune (1884) and Nieden (1910) and photographs of preserved material in Perret & Amiet (1971) and of living specimens in Perret (1966) and Amiet (1975, 1989).



PLATE 1. *Bufo tuberosus* female, Ngam, Sangmelima, Cameroun.

TABLE 6. Some diagnostic differences between linear morphological characters of adults of *Bufo tuberosus* and species of *Bufo* from west and central Africa and those all species of the *B. regularis* Complex. * species known from west of the Dahomey Gap. A difference (+) indicates that ranges of variation do not overlap. Lack of a diagnostic difference does not indicate lack of a statistical difference. These comparisons have not been tested for statistical significance. For data on other species, see Table 7 in Largen *et al.* (1978), Table 12 in Tandy *et al.* (1982) and Tables 1, 9 and 16 in Tandy & Feener (1985).

Species	SU	HW	HL	T	E	PL	PW	UH	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/UH	Diagnostic	Not diagnostic
<i>B. anietii</i> *	+	+	+	+	+			+						+				8	9
<i>B. gracilipes</i>	+	+	+			+	+	+										6	11
<i>B. villiersi</i>																		0	17
<i>B. regularis</i> *																+		1	17
<i>B. superciliaris</i> *	+	+	+	+	+	+		+				+		+				9	8
<i>B. gammani</i>												+				+		2	15
<i>B. latifrons</i>															+	+		2	17
<i>B. togoensis</i> *						+						+						2	15
<i>B. brauni</i>	+	+		+	+	+						+				+		8	9
<i>B. gutturalis</i>												+			+	+		3	14
<i>B. kisolensis</i>				+														1	16
<i>B. poweri</i>	+	+		+		+						+				+		6	11
<i>B. rangeri</i>	+	+						+				+				+		5	12
<i>B. camerunensis</i> *																		1	16
<i>B. kerinyagae</i>						+						+	+			+		4	13
<i>B. xeros</i> *	+	+		+		+		+				+				+		7	10
<i>B. asmarae</i>	+					+		+				+	+			+		6	11
<i>B. maculatus</i> *																+		1	16
<i>B. danielae</i> *	+	+						+				+						4	13
<i>B. blanfordi</i>	+	+																2	15
<i>B. langanoensis</i>												+				+		3	14
<i>B. turkanae</i>	+	+						+				+						6	11
<i>B. perreti</i>									+			+			+	+		4	13
<i>B. steindachneri</i>	+	+	+				+	+				+				+		7	10
<i>B. pentoni</i> * - Senegal			+													+		2	15
Males																			
<i>B. amietii</i> *	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>B. gracilipes</i>		+						+										2	15
<i>B. villiersi</i>	+	+				+		+										5	12
<i>B. regularis</i> *												+				+		2	15
<i>B. superciliaris</i> *	+	+	+	+	+	+	+	+	+			+	+		+			12	5
<i>B. garmani</i>	+	+	+	+	+	+		+				+				+		9	8
<i>B. latifrons</i>																+		1	16
<i>B. togoensis</i> *												+			+			2	15
<i>B. brauni</i>	+	+	+	+	+	+		+				+				+		9	8
<i>B. gutturalis</i>	+	+	+	+	+	+						+	+		+	+		10	7
<i>B. kisolensis</i>	+	+	+			+						+			+	+		6	11
<i>B. poweri</i>	+	+	+	+	+	+	+	+		+		+				+		11	6
<i>B. rangeri</i>	+	+	+	+	+	+		+				+	+			+		10	7
<i>B. camerunensis</i> *												+			+			2	15
<i>B. kerinyagae</i>	+					+						+			+			5	12
<i>B. xeros</i> *	+	+		+		+		+				+			+			7	10
<i>B. asmarae</i>	+					+		+				+			+			5	12
<i>B. naculatus</i> *																+		1	16
<i>B. danielae</i> *																+		1	16
<i>B. blanfordi</i>							+											1	16
<i>B. langanoensis</i>												+				+		3	14
<i>B. turkanae</i>												+			+	+		3	14
<i>B. perreti</i>												+			+			2	15
<i>B. steindachneri</i>												+				+		3	14
<i>B. pentoni</i> * - Senegal												+				+		2	15

Günther's description focused on the extreme wartiness of the skin, but did not give measurements or ratios of body parts. The sex of the holotype was not specified nor was its exact locality on the island of Bioko (Fernando Poo) (Günther, 1858). Boulenger later published a more detailed description with some measurements and verbal proportions, however he mistakenly identified the holotype as a male and his measurements for that specimen differ from ones made more recently.

The very prominent parotoids were noted by Boulenger (1880) and by subsequent authors such as Noble (1924), Perret (1966) and Perret & Amiet (1971). The data in Tables 1 and 6 demonstrate the markedly low ratio of parotoid length to width and also the very small size of the tympanum compared to parotoid width. The ratio of T/PW separates *B. tuberosus* diagnostically (ranges of variation do not overlap) from 18 (in females) or 21 (in males) of the 25 other African *Bufo* species compared. As summarized in Table 6, *B. tuberosus* differs diagnostically in at least one of these measurements or their ratios from all of the species compared except for females of *B. villiersi*.

Boulenger (1900) mentioned a crimson vertebral line in some specimens from the Rio Uoro (Rio Benito), Rio Muni, Guinea Ecuatorial. That color has now faded in those specimens.

Noble (1924) noted variation in ventral coloration in his material from the eastern République Démocratique du Congo ranging from heavy to no dark mottling.

Parker (1936b) gave ratios of body to foot length and interpreted this as demonstrating relatively short legs of *B. tuberosus* compared to other species. Perret (1966) gave ranges of variation of body and tibia lengths for each sex and ratios of parotoid gland length/width and body length/tibia length. These data do not appear to support Parker's appraisal of relative leg length, although Perret did not give arithmetic means of his ratios (only ranges) nor did he test such for statistical significance. Although differences of means given in Table 1 have not been tested for significance, the data on ratios of snout-urostyle length/urostyle heel length do not support Parker's judgement about leg length in this species. Those data indicate that *B. tuberosus* is one of the longer legged species.

Perret (1966) noted the marked sexual dimorphism of body size in this species. Tables 1 and 7 illustrate this dimorphism in linear characters. All measurements are at least statistically smaller in males than females, and two are diagnostically different. Most ratios do not differ between the sexes, although females have statistically narrower heads relative to body size (SU/HW) and smaller tympani relative to parotoid width (T/PW).

TABLE 7. Sexual dimorphism of linear morphological characters in *Bufo tuberosus*. D - difference diagnostic, ranges of variation do not overlap. S - statistically significant difference $P < 0.01$. - no statistical difference

															Number of characters				
SU	HW	HL	T	E	PL	PW	UH	SU/HW	HW/HL	T/HW	PL/PW	HW/PL	T/PL	HW/PW	T/PW	SU/UH	Diagnostic	Statistical	Not diagnostic
D	S	S	S	S	S	S	D	S	-	-	-	-	-	-	S	-	2	8	7

Perret (1966) stated that he had not found vocal sac openings in males except for one with a single opening on the left. Perret & Amiet (1971) made a similar statement. Table 3 shows numbers and locations of vocal sac openings in the eight adult males examined. Two lack openings.

MATING CALL

Basic physical structure. The mating call of *Bufo tuberosus* is a series of low pitched hooting sounds that lack the noisy quality of the calls of most African *Bufo*. They are also not as loud as those of many other species (Amiet, 1976). The physical structure of these calls is similar to that of species of the *B. regularis*, *B. maculatus*, *B. blanfordi*, *B. funereus* (except *B. villiersi*), and *B. pentoni* groups and also some species of the *B. vertebralis* Complex and *B. angusticeps* group (Tandy, 1972; Tandy & Keith, 1972; Tandy & Tandy, 1976). Each complex pulse train (series of hoots) contains a variable number of simple pulse trains repeated at a rate of about 1.6 per second in specimens from Cameroun (Table 8). Each simple pulse train contains about 17 passive pulses repeated at a rate of 87 per second (89.74/sec at about 24°C). The duration of simple pulse trains is about 0.2 second (.18 at 24°C). The low emphasized frequency is the dominant frequency at about 526Hz. Sonagrams show three harmonics above the low emphasized frequency, but these contain less than half the energy of the low emphasized frequency. These frequencies show a slight gradual rise at the ends of simple pulse trains. These data are based on calls of only two recorded specimens. See material studied for times and places.

Amiet (1976) described and illustrated a sonagram of a call of a male *B. tuberosus* uttered while trying to clasp a plastic bag containing another male which Amiet termed a "cri de rivalité". This call is structurally very similar to male release calls uttered by many *Bufo* species, and the context indicates that is what it was. It is very different from the mating call in structure and function.

TABLE 8. Physical characteristics of the mating calls of *Bufo tuberosus*. PPR = passive pulse repetition rate; NPP/PT = number of passive pulses per simple pulse train; PT DUR = simple pulse train duration; PTR = simple pulse train repetition rate; LOW EMP = low emphasized frequency; DOM = dominant frequency; n = number of individuals per sample.

	N	PPR (/sec)	NPP/PT	PT DUR (/sec)	PTR (/sec)	LOW EMP (Hz)	DOM (Hz)
<i>Bufo tuberosus</i> Kala, Cameroun	1	84.80	18.60	0.230	1.30	547.0	547.0
Sta. 141 nr Ting, Cameroun	1	89.74	15.96	0.178	1.92	505.0	505.0

Circadian and seasonal calling behavior. In April, 1971, Tandy found a mixed chorus of *Bufo gracilipes* and *B. tuberosus* calling along a small stream at dusk in secondary forest near Ting, Cameroun. The *B. gracilipes* called in water holding onto living aquatic plants and vegetative debris in the middle of the stream. *B. tuberosus* called from very well-concealed sites among overhanging roots of forest vegetation beneath the undercut stream bank. Amiet (1973, 1976, 1989) was able to make

additional observations of this behavior. The above two species and *B. villiersi* are the only Camerounian *Bufo* known to typically call during daylight, and these species are atypical of most species in the genus.

Amiet (1976) has found that *B. tuberosus* choruses are usually small, often less than a dozen individuals. He also observed one larger aggregation near Yaoundé, Cameroun.

In Cameroun, *B. tuberosus* breeds during the dry season and at the beginning of the rainy season principally January-March (Amiet, 1976).

Comparisons with other species. The mating call of *B. tuberosus* is as distinctive as its morphology. Table 10 compares the acoustic structure to those of twenty African species including all species whose mating calls are known from west and central Africa and all members of the *B. regularis* Complex (Tandy & Tandy, 1976). See also data in Tandy *et al.*, 1976; Largen *et al.*, 1978; and Tandy *et al.*, 1982 and 1985. The call of *B. tuberosus* appears to differ diagnostically (ranges of variation do not overlap in data available) in at least 3 characters from all twenty species. This comparison must be considered tentative because of the small sample size (2) available for *B. tuberosus*, but the comparisons are probably valid because of the much larger data sets available for most of the other species.

Only *B. gracilipes* has been observed calling at the same time and locality as *B. tuberosus*, although *B. camerunensis* has been observed breeding nearby. Other species of the central African rain forests that might breed in the same areas include *B. latifrons*, *B. maculatus* and *B. superciliaris*. The latter is thought to lack a mating call (Amiet, 1976).

The call of *B. tuberosus* differs in five of six apparently homologous characters from *B. gracilipes*, *B. villiersi* and *B. perreti* and it also differs qualitatively from those species. The mating calls of the above three species are first order sequences of complex pulse trains whereas that of *B. tuberosus* is just one complex pulse train.

The voice of *B. camerunensis* differs in all six call characters compared. The PPR is slower in *B. camerunensis*, the NPP/PT and PT DUR two to three times greater and PTR is one third to one fourth its rate in *B. tuberosus*.

The mating call of *B. latifrons* is different in all six characters. PT DUR in *B. tuberosus* is about one fifth, PPR is more than three times faster and PTR is two to four times faster than in *B. latifrons*.

The voice of *B. maculatus* differs in four characteristics. PPR and PT DUR are about twice, NPP/PT four times and PTR up to twice greater than in *B. tuberosus*.

The call of *B. regularis* differs in three characters. PPR is less than a third, PT DUR is about four times greater and PTR less than one half those in *B. tuberosus*. These two species are not likely to be sympatric because of different habitat preferences.

None of the other species in Table 9 is likely to be sympatric with *B. tuberosus*. Their calls differ from the latter species in at least three characters.

TABLE 9. Apparent differences and similarities between the mating calls of *Bufo tuberosus* and 19 species of *Bufo* from west or central Africa and all those known of species of the *B. regularis* Complex. * species known from west of the Dahomey Gap. ^ species of central Africa. These comparisons are tentative because of the small number of specimens recorded for *B. tuberosus* (n=2). A difference (+) indicates that ranges of variation do not overlap. These comparisons cannot be tested for statistical significance because of the small sample size for *B. tuberosus* and a few of the other species. (1) - species for which number of specimens analyzed is less than 10. For data on other species, see Table 1 in Tandy *et al.* (1976), Table 2 in Largen *et al.* (1978), Table 1 in Tandy *et al.* (1982), and Table 14 in Tandy & Feener (1985). (2) Comparison is between homologous characters rather than those of the same grade of physical complexity (See Tandy & Tandy, 1976).

Species compared	PPR	NPP/PT	PT DUR	PTR	LOW EMP	DOM	Number of characters	
							Different	Similar
<i>B. gracilipes</i> ^	+	+(2)	+(2)	-?	+	+	5	1?
<i>B. villiersi</i> ^(1)	+	+(2)	+(2)	-?	+	+	5	1?
<i>B. regularis</i> *^	+	-	+	+	-	-	3	3
<i>B. garmani</i>	-	+	+	-	-	+	3	3
<i>B. latifrons</i> ^(1)	+	+	+	+	+	+	6	0
<i>B. brauni</i>	-	+	+	+	+	+	5	1
<i>B. gutturalis</i>	+	-	+	+	-	-	3	3
<i>B. kisoaloensis</i> ^(1)	-	+	+	+	-	+	4	2
<i>B. poweri</i>	+	+	+	-	-	+	4	2
<i>B. rangeri</i>	+	+	-	-	+	+	4	2
<i>B. camerunensis</i> *^	+?	+	+	+	+	+	6	0
<i>B. kerinyagae</i> (1)	+	+	+	+	+	+	6	0
<i>B. xeros</i> *^	+	+	-	-	+?	+?	4	2
<i>B. asmarae</i>	+	+	+	+	-	+	5	1
<i>B. maculatus</i> *^	+	+	-?	-?	+	+	4	2
<i>B. langanoensis</i> (1)	+	+	+	+	+	+	6	0
<i>B. turkanae</i> (1)	+	-	+	+	+	+	5	1
<i>B. perreti</i>	-	+(2)	+(2)	+?	+	+	5	1
<i>B. steindachneri</i> ^(1)	+	+	-	-	+	+	4	2
<i>B. pentoni</i> *^ - Senegal (1)	+	+	+	+	+	+	6	0

GEOGRAPHIC DISTRIBUTION AND ECOLOGY

Bufo tuberosus is known from fiftyone equatorial lowland rainforest localities in Cameroun, Guinea Ecuatorial (Bioko and Rio Muni), Gabon, République du Congo, République Centrafricaine and République Démocratique du Congo between latitudes 0°5'S and 5°14'N and longitudes 8°33' and 29°15'E (Fig. 5). These are in an altitudinal range of 10 to 1266m. See Table 4 for climatic data.

Ecological data in Tables 4 and 10 indicate that *B. tuberosus* localities differ diagnostically from those of fifteen of the 25 species compared. *B. tuberosus* is not likely to be sympatric with any of those.

Among the remaining ten species, seven occur in central Africa, *B. gracilipes*, *B. superciliaris*, *B. latifrons*, *B. camerunensis*, *B. maculatus* and *B. steindachneri*. As noted above, *B. tuberosus* has been found syntopic only with *B. gracilipes*. But it is likely to occur within close proximity of all of these except *B. steindachneri*. The latter occurs primarily in marshy sites surrounded by arid savanna.

B. tuberosus is known only from forested localities, so it is not so likely to occur with *B. regularis* or *B. maculatus* which often prefer more open habitats.

The other high forest species, *B. gracilipes*, *B. superciliaris*, *B. latifrons* and *B. camerunensis* are most likely to occur with *B. tuberosus*.

As noted previously, the ecology of *B. tuberosus* sites is very much like that of the allopatric *B. amieti*.

TABLE 10. Apparent differences and similarities between the ecological characteristics of *Bufo tuberosus* and species of *Bufo* from west or central Africa and those of all species of the *B. regularis* Complex. * species known from west of the Dahomey Gap. ^ species known from central Africa. Some of these comparisons are tentative because of the small number of known localities for some species. A difference (+) indicates that ranges of variation do not overlap. These comparisons have not been tested for statistical significance. (1) - species for which number of localities is less than 10. For data on other species, see Tables 3 in Tandy *et al.* (1976) and Tandy *et al.* (1982), Table 8 in Tandy *et al.* (1985), and Table 13 in Tandy & Teener (1985).

Species compared	Elevation	Mean Annual Temperature	Mean Annual Rainfall	Different	Similar
<i>B. Amieti</i> (1)	-	-	-	0	3
<i>B. gracilipes</i> ^	-	-	-	0	3
<i>B. villiersi</i> ^ (1)	+	-	-	1	2
<i>B. regularis</i> *^	-	-	-	0	3
<i>B. superciliaris</i> *^	-	-	-	0	3
<i>B. garmani</i>	-	-	+	1	2
<i>B. latifrons</i> ^ (1)	-	-	-	0	3
<i>B. togoensis</i> (1)	-	-	+	1	2
<i>B. brauni</i> (1)	-	+	-	1	2
<i>B. gutturalis</i>	-	-	+	1	2
<i>B. kisoensis</i> ^	-	+	-	2	1
<i>B. poweri</i>	-	-	+	1	2
<i>B. rangeri</i>	-	+	-	1	2
<i>B. camerunensis</i> *^	-	-	-	0	3
<i>B. kerinyagae</i>	+	+	-	2	1
<i>B. xeros</i> *^	-	-	+	1	2
<i>B. asmarae</i>	-	-	+	1	2
<i>B. maculatus</i> *^	-	-	-	0	3
<i>B. danielae</i> * (1)	-	-	-	0	3
<i>B. blanfordi</i>	-	-	+	1	2
<i>B. langanoensis</i> (1)	-	-	+	1	2
<i>B. turkanae</i> (1)	-	+	+	2	1
<i>B. perreti</i> (1)	-	-	-	0	3
<i>B. steindachneri</i> ^	-	-	-	0	3
<i>B. pentoni</i> *^ - Senegal (1)	-	-	+	1	2

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